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TITLE:

A device for treatment of a gas flow.

TECHNICAL FIELD:

The invention generally relates to a device for treatment of a gas flow. In particular, the invention relates to a device for catalytic purification of exhaust gases emanating from internal combustion engines.

BACKGROUND ART:

Exhaust gases emanating from e.g. internal combustion engines or industrial processes generally contain potentially hazardous compounds such as hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x) and particulates. Such compounds need to be converted to harmless, or at least less hazardous, compounds in order to reduce the amount of hazardous compounds released to the environment. Commonly, the exhaust gases undergo some form of catalytic treatment and/or filtering process.

In most of the conversions of interest in this context, the temperature is an important feature. Many important conversion reactions require a rather high temperature. The use of catalysts, e.g. metals or metal oxides from the platinum group, makes it possible to convert the hazardous compounds with a satisfactory reaction rate at a much lower temperature than if catalysts are not used. However, a high reaction rate can only be achieved if the temperature is sufficient, i.e. above the so called light-off temperature at which the catalyzed reaction rate becomes significant. The light-off temperature is usually in the range 200-400°C. If the light-off temperature has not yet been reached, or if the temperature falls below light-off so that the conversion stops, almost no hazardous compounds will be converted. These are well-known problems associated with e.g. cold start of an engine (with a similarly cold catalyzer) and with "cold" exhaust gases, such as those emanating from a diesel engine.

The temperature is further important in regeneration of purification devices, e.g. the removal of trapped particles by combustion or the removal of impurities such as sulphur oxides (SO_x) from a catalytic device. Such processes can be cyclic and involve a temperature increase to

around 600°C for a certain time period. As the purification devices normally degrade if they are exposed to too high temperatures there is an upper temperature limit that should not be exceeded. Thus, it is not only the temperature that is an important feature, but also the control of the temperature; both at normal operation to achieve a good conversion and during regeneration processes.

A conventional physical structure of a catalytic converter, as for instance disclosed in US 3885977, is the ceramic honeycomb monolith with parallel, open channels. The catalytic material is deposited onto the walls of the honeycomb channels. As the gas flows from one end to the other, the catalytic conversion takes place. This type of structure generally works well provided that the temperature of the device is above the light-off temperature. However, at cold-start situations the hazardous compounds flow through the channels without conversion.

In order to reduce the amounts of hazardous compounds that are released during cold start it is a well known technique to use adsorption traps, i.e. to deposit a material, besides the catalysts, that adsorbs and retains cold hydrocarbons and/or nitrogene oxides until the catalyst reaches the light-off temperature. As an example, this is disclosed in WO95/18292. A problem with this technique when applied to the conventional physical structure described above is that the desorption temperature for most compounds generally is lower than the temperature required for conversion. A great deal of the hazardous compounds will thus still flow through the channels without conversion.

Another approach to solve the problem with cold converters is to introduce electric heating, as disclosed in for instance WO92/14912. It is however difficult to make the heating fast enough and the costs for components and energy are high. This kind of electric heating may also be a safety risk (electricity, fire).

Another important feature is the pressure drop over the purification device as energy is needed to overcome the gas flow resistance of the device. For instance, an increased pressure drop over a purification device for a vehicle engine could result in an increased fuel consumption.

An interesting technique that has been proposed more lately is the combination of a catalytic purification device and a heat exchanger permitting heat exchange between the incoming gas and the outgoing gas. This technique makes it possible to utilize the heat in the exhaust gas in a more efficient way which is an advantage under most, if not all, operation conditions. EP 1016777 discloses a construction that consists of a corrugated metal strip that is folded onto itself into a bundle that forms gas flow passages between the foldings. However, the shape of the corrugation of the metal strip forms a number of small passages within each larger passage between the foldings, and as the incoming gas flow enter the larger passages from their side, most of the gas will flow in the small passages that are located closest to the side from which the gas was fed. In other words, the gas enters the bundle from the side and due to difficulties to flow across the larger passages, the gas flow will not be distributed within the width of the larger passages. This leads to an overall gas flow distribution that will be non-uniform. Although this construction is of principal interest the uneven flow distribution over the catalyst may lead to an insufficient conversion, a less efficient heat exchange and to a high pressure drop over the construction. Furthermore, metal constructions are generally prone to degrade in the rough environment of an exhaust gas flow.

DISCLOSURE OF THE INVENTION:

One object of the present invention is to provide a device for treatment of a gasflow that, compared to prior art, converts the gas more efficiently and exhibits a lower pressure drop. This objective is achieved by the technical features contained in the characterizing portion of claim 1. The following claims contain advantageous embodiments, further developments and variants of the invention.

The invention concerns a device for treatment of a gas flow, comprising at least one body, at least one first opening for entrance of an incoming gas flow to said body and at least one second opening for the exit of an outgoing gas flow from said body, wherein said body is provided with a plurality of gas flow passages arranged to permit heat exchange between the gas flows in adjacent passages. The invention is characterized in that the device comprises at least one distribution section in communication with the first opening and with the gas flow passages to distribute the incoming gas flow to the gas flow passages, and at least one gas flow passage section including said gas flow passages, which passage section primarily is adapted to permit heat exchange and to cause a conversion in the composition of the gas. An advantageous effect of this feature is that an improved gas flow distribution is achieved which

makes it possible to both utilize the potentially available surfaces within the gas treatment device in a more efficient way, and to lower the pressure drop over the construction. A more efficient utilization of the surfaces can for instance be used to achieve a further conversion (e.g. purification) of the gas, to decrease the space required for the device by making it smaller, and to make the device cheaper by decreasing its content of catalytic material for a given level of conversion.

In an advantageous embodiment of the invention, the distribution section is adapted to distribute the incoming gas flow within the individual gas flow passages. This way the gas flow will not only be distributed among the different flow passages, but also within the individual passages which further increases the potential efficiency of the device. Preferably, the distribution section is adapted to bring about a substantially uniform gas flow within the individual gas flow passages.

In a second advantageous embodiment of the invention, the distribution section forms a part of the body. Preferably, the distribution section is in communication with the second opening to also lead the outgoing gas flow out from the gas flow passages. Such an arrangement makes it possible to give the device a compact design. Additionally, it makes it possible to perform heat exchange also in the distribution section.

In a third advantageous embodiment of the invention, the gas flow passages extend essentially parallel to each other, and further is the main direction of the gas flow in one gas flow passage essentially the opposite of the main direction of the gas flow in an adjacent gas flow passage. Thereby it is possible to achieve a counter-current heat exchange process for highest efficiency.

In a fourth advantageous embodiment of the invention, the body comprises a strip that is folded into a zig-zag structure, and spacer means are arranged between the foldings of the zig-zag structure in such a way that a distance is achieved between two foldings that face each other in the zig-zag structure, and the gas flow passages thereby are formed between the foldings of the zig-zag structure, and said spacer means are arranged to facilitate the distribution of the incoming gas flow in the distribution section. This arrangement allows the gas to freely flow across the gas flow passages and thus be distributed within the width of the passages. An advantageous effect of creating the gas flow passages in a folded strip by using

spacer means is that it is a flexible system and it gives many possibilities to arrange the distribution section. Another advantageous effect is that it gives increased freedom in the design of the surface of the strip; the surface may for instance be essentially non-patterned to decrease the flow resistance.

In a fifth advantageous embodiment of the invention, the body comprises a strip that is folded into a zig-zag structure, and the surface of the strip at least partly exhibits a three-dimensional pattern, preferably corrugations, and said three-dimensional pattern is arranged to give rise to contact points and gaps between two foldings that face each other in the zig-zag structure, and the gas flow passages thereby are formed in the gaps between the foldings of the zig-zag structure, and the surface of at least one of two foldings that face each other differ from said three-dimensional pattern in the distribution section in such a way that the distribution of the incoming gas flow is facilitated. Also this arrangement allows the gas to freely flow across the gas flow passages and thus be distributed within the width of the passages. An advantageous effect of creating the gas flow passages and the distribution section in a folded strip by using different kinds of surface patterns is that the construction contains fewer parts.

In a sixth advantageous embodiment of the invention, the distribution section and the gas flow passage section form separate units that are arranged together in such a way that gas can flow from one section to the other, preferably the distribution section and the gas flow passage section are joined to each other. Thereby the sections can be produced individually which makes it possible to optimize the production process and make it more cost-effective.

In a seventh advantageous embodiment of the invention, the distribution section comprises a wall structure forming at least one first channel to which the incoming gas flow is fed, and a plurality of second channels that extend from said first channel and which second channels are open to the gas flow passages that are intended for an incoming gas flow. This enables a simple construction and a good distribution of the incoming gas flow. Preferably, said first channel is closed to the gas flow passages. Thereby the incoming gas is forced to flow via the second channels which leads to an even more uniform distribution. In a further improvement, the wall structure forms a plurality of third channels that are open to the gas flow passages that are intended for an outgoing gas flow, preferably said third channels are formed between said second channels using common walls. This is an advantageous way of leading the gas out

as heat exchange can take place also in the distribution section, and as no additional walls are needed.

In an eighth advantageous embodiment of the invention, the distribution section comprises a zig-zag shaped wall structure forming a first and a second set of channels, one set on each side of said zig-zag shaped structure, wherein said first set of channels are open to the gas flow passages that are intended for an incoming gas flow and said second set of channels are open to the gas flow passages that are intended for an outgoing gas flow, and wherein the incoming gas flow is fed to the first set of channels. Also this design enables a simple construction and a good distribution of the incoming gas flow.

In a ninth advantageous embodiment of the invention, the distribution section exhibits in at least one certain direction a substantially unchanged cross section. Thereby it is possible to produce the section by extruding means which is an cost-effective production process.

Preferably, the distribution section and the gas flow passage section are made out of a ceramic material, and the sections joined to each other by sintering means. This gives a favourable construction since a ceramic material, compared to metal, has a lower cost of material, a lower cost of production, a lower thermal expansion, a better wash-coat adhesion and has a lower thermal mass per wall volume. A construction made out of a ceramic material is also less prone to degrade in the rough environment of an exhaust gas flow.

In a tenth advantageous embodiment of the invention, the body has a substantially cylindrical shape, preferably the body has a general shape of a circular cylinder, and the body comprises an internal cavity that extends in the longitudinal direction of the body, and at least one first or second opening is directed towards said cavity so that the gas flow at least partly is led via said cavity. An advantageous effect of this design is that the device require less space. A further advantage, especially in a vehicle exhaust gas purification application, is that the device can be made with a long and narrow physical shape that can be arranged with its longitudinal axis in line with the exhaust pipe. By distributing the gas flow passages around the internal cavity and/or along the longitudinal axis of the body, this design enables a low pressure drop and advantageous packing properties.

BRIEF DESCRIPTION OF THE DRAWINGS:

The invention will now be described in more detail with reference to the following drawings where:

Figure 1 in an overview shows an example of a method for producing and constructing a gas treatment device according to a first advantagous embodiment of the invention,

Figure 2 shows in more detail the first advantageous embodiment of the invention according to figure 1,

Figure 3 shows, in an exploded perspective view, a second advantageous embodiment of the invention,

Figure 4 shows a schematic sectional view of a variant of the second advantageous embodiment of the invention according to figure 3,

Figure 5 shows a sectional view A-A according to figure 4,

Figure 6 shows a sectional view B-B according to figure 4,

Figure 7 shows a sectional view C-C according to figure 4

Figure 8 shows a sectional view D-D according to figure 4,

Figure 9 shows a sectional view A-A according to figure 4 of an alternative variant of the second advantageous embodiment of the invention,

Figure 10 shows a sectional view B-B according to figure 4 corresponding to the variant shown in figure 9, and

Figure 11 shows a further development of the second embodiment of the invention according to figures 3 and 4.

DETAILED DESCRIPTION OF THE INVENTION:

Figure 1 shows in an overview an example of a method for producing and constructing a gas treatment device according to a first advantagous embodiment of the invention. A strip 1 is folded into a zig-zag structure 2. Spacer means in the form of corrugated plates 9 are arranged between the foldings 10 of the zig-zag structure 2 in such a way that a distance is achieved between two foldings 10 that face each other in the zig-zag structure 2. This distance makes it possible to feed a gas flow between the foldings 10. The corrugated plates 9 are arranged to leave some central space free from spacer means. This free space forms a part of a distribution section 26 that will be further described in relation to figure 2. The zig-zag structure 2 may be formed to bodys of different geometrical shapes, depending on e.g. the application of the device. In figure 1 the zig-zag structure 2 forms a body 3 with the shape of a bundle. The body 3 is placed into a casing 6 that encloses the body 3, and the casing 6 is provided with a

first opening 4 for entrance of an incoming gas flow to the body 3 and a second opening 5 for the exit of an outgoing gas flow from the body 3. Sealings 7 prevent gas from flowing under or over the body 3. In order to adapt the body 3 to cause a conversion in the composition of the gas, at least a part of the surfaces of the body 3 that are in contact with the gas flow are preferably coated with a catalyst material.

Figure 2 shows in more detail the first advantageous embodiment of the invention according to figure 1. For the sake of clarity, the zig-zag structure is partly unfolded. Due to the arrangement of the corrugated plates 9, a plurality of gas flow passages 11a, 11b are formed between the foldings 10 in the body 3. Every second of said gas flow passages 11a, 11b are open to the first opening 4; referred to as the gas flow inlet passages 11a. The other passages, the gas flow outlet passages 11b, are open to the second opening 5. The incoming gas is fed via the first opening 4 into the distribution section 26 in which it divides into two main flows with opposite directions (to the left and to the right as seen from the direction of the incoming gas flow) and enters the inlet passages 11a in each of the gas flow passage sections 27. At both ends of the casing 6 the gas flow enters a reversing chamber 13 where the gas leaves the inlet passages 11a and enters the outlet passages 11b through which the gas flows to the second opening 5 and exits the casing 6. A counter-current heat exchange is thus permitted between adjacent gas flow passages.

Inside the first opening 4 the distribution section 26 is located, in which section the corrugated plates 9 are arranged to facilitate the distribution of the incoming gas flow over the width of the gas flow inlet passages 11a. As mentioned above, the distribution section 26 is in this case formed by a void in the presence of plates 9 so that the incoming gas easily can flow across the inlet passages 11a. Thereby the gas flow can be uniformly distributed over the width of the individual inlet passages 11a. As the gas passes the distribution section 26, it enters a gas flow passage section 27 comprising the corrugated plates 9. Thus, the device comprises one distribution section 26 and two gas flow passage sections 27. In addition, the device comprises two reversing zones in the form of reversing chambers 13. Since the structure of the distribution section 26 in figure 2 is similar inside both the first opening 4 and the second opening 5, the distribution section 26 also facilitates the transport of the outgoing gas flow out from the outlet passages. This feature reduces the pressure drop over the construction.

The spacer means are not limited to corrugated plates 9, but can for instance comprise a mesh-wire net. Further, the spacer means may exhibit filtering properties for removal of particulates. Filtering material may also be placed in the distance between the foldings 10.

As an alternative to spacer means, the surface of the strip 1 may exhibit a three-dimensionell pattern, preferably corrugations, arranged to give rise to contact points and gaps between two foldings 10 that face each other in the zig-zag structure 2. The frequency of the corrugations may for instance differ between adjacent foldings 10. Alternatively, the phase of the corrugations may be shifted between adjacent foldings 10. The gas flow passages 11a, 11b are thereby formed in the gaps between the foldings 10. Preferably, said three-dimensionell pattern extends over an area of the foldings 10 corresponding to the area covered by the corrugated plates 9 in figures 1 and 2. The distribution section 26 can thus be located inside the first opening 4 in a similar way as shown in figure 2. In this distribution section 26, the surfaces of the foldings 10 can be arranged to differ from said three-dimensional pattern, the surfaces may for instance be substantially non-patterned, so that no, or only a few, contact points are created in the distribution section 26. The effect of this arrangment is similar to what is described above, i.e. that the incoming gas can easily flow across the inlet passages 11a in the distribution section 26 and thereby the gas flow can be uniformly distributed over the width of the inlet passages 11a.

A second advantageous embodiment of the invention is shown in figures 3 to 10. In this embodiment the distribution section and the gas flow passage section form separate units that are joined to each other. Figure 3 shows, in an exploded perspective view, the structure of a body 3 comprising one distribution section 26, two gas flow passage sections 27 and two reversing zones in the form of reversing chambers 13. Each passage section 27 is provided with a plurality of gas flow passages 11 and, compared with the thin walls defining the gas flow passages 11, relatively thick supporting walls 33 that divides the gas flow passage section into a number of sectors. The body 3 has the shape of a circular cylinder and comprises an internal cavity 20 that extends in the longitudinal direction of the body. The incoming gas flow is fed into the body 3 via the internal cavity 20 and the outgoing gas flow leaves the body 3 via its periphery. These flow processes are further described below.

Figure 4 shows a schematic sectional view of a variant of the second embodiment wherein the body 3 constitutes two sub-bodies that have been joined together, and wherein each sub-body

has a structure according to figure 3. The body 3 has also been provided with surrounding equipment for leading the gas to and from the body 3. Figure 5, 6, 7 and 8 shows sectional views A-A, B-B, C-C and D-D, respectively, according to figure 4. The structure of the distribution section 26 is not shown in figure 4, but in figure 5.

The incoming gas flow is fed into the body 3 through the first opening 4 into the internal cavity 20. The other end 23 of said cavity 20, opposite to that of the first opening 4, is closed which has the effect that the incoming gas flow is forced through the first openings 4' of each distribution section 26. As can be seen in figure 5, the distribution section 26 constitutes of a wall structure forming (as an example) four first channels 29 that communicate with the internal cavity 20 via the first openings 4' and to which first channels 29 the incoming gas flow is fed. The wall structure further forms a plurality of second channels 30 (in the figure there are, as an example, five in each direction) that extend from each of said first channels 29. As can be seen in figure 6, the gas flow passage section 27 is provided with a plurality of gas flow passages 11a, 11b. Every second of these passages forms an inlet passage 11a intended for an incoming gas flow, and every second passage forms an outlet passage 11b, intended for an outgoing gas flow. Said second channels 30 (fig. 5) are open to the gas flow inlet passages 11a, whereas said first channels 29 are closed to all gas flow passages 11a, 11b by the ends of the supporting walls 33. In order to make it possible to use thinner supporting walls 33 and thereby decrease the amount of construction material in the body, the direct passage from the first channels 29 to the gas flow passages 11a, 11b can be closed by blocking means, for instance thin plates, or by plugging appropriate parts of the passages. As the incoming gas flow is fed through the first openings 4' into the first channels 29, the gas is forced to be distributed into the second channels 30. From the second channels 30, the gas flow is fed to the inlet passages 11a. Further, the gas flows through the inlet passages 11a and enters the reversing chamber 13 allowing the gas flow to change direction and flow back to the distribution section 26 via the outlet passages 11b. The wall structure forming the first channels 29 and the second channels 30 in the distribution section 26 also forms a plurality of third channels 32 (in the figure there are, as an example, five in each direction) between said second channels 30 using common walls. Said third channels 32 are open to the gas flow outlet passages 11b. Two sets of said third channels 32 emerge into a common fourth channel 34. In figure 5 it can be seen that the distribution section 26, as an example, is provided with four fourth channels 34. The outgoing gas flow enters said third channels 32 from the outlet passages 11b and exits the distribution section 26 via said fourth channels 34 and a second

opening 5' into an outlet channel 35 in the periphery of the body 3. At the end of the body 3, opposite to that of the first opening 4, the outlet channels 35 are combined to a common second opening 5 for the exit of the outgoing gas flow from the body 3.

Figure 7 shows a sectional view of the section comprising the reversing chamber 13. As a variant, the reversing chamber 13 could be divided up into a number of sectors. Figure 7 also shows the internal cavity 20 and the outlet channels 35. Figure 8 shows a sectional view of a delimiting plate 24 located between the two sub-bodies. Such plates 24 can be used to stabilize the construction. As an alternative to what is shown in figure 4, the delimiting plate 24 may form the end part of the reversing chambers 13 of two adjacent sub-bodies.

In order to lead the gas to the body 3, a pipe (for instance an exhaust pipe) is preferably inserted through the first opening 4 all the way to the other end 23 of the internal cavity 20. By providing the pipe with openings around its circumference at a location corresponding to the location of the distribution section(s) 26, the gas is permitted to flow into the distribution section(s) via the first openings 4'. A pipe provided with openings can also be inserted through the second opening 5 in order to lead the gas away from the body 3. Such inserted pipes can be used to stabilize the construction.

Figure 9 and 10 show an alternative variant of the second embodiment of the invention. The principal of this variant is similar, but the distribution section and the gas flow passage section has a different internal shape. Figure 9 shows a sectional view A-A according to figure 4 of the alternative distribution section 26', and figure 10 shows a sectional view B-B according to figure 4 of the alternative gas flow passage section 27'. Refering to figure 9, the distribution section 26' comprises a zig-zag shaped wall structure forming a first set of channels 40 and a second set of channels 41, one set on each side of said zig-zag shaped structure. The first set of channels 40 are, via the first openings 4', open to the internal cavity 20 and to the gas flow passages that are intended for an incoming gas flow: the inlet passages 11a. The second set of channels 41 are open to the gas flow passages that are intended for an outgoing gas flow: the outlet passages 11b, and to the outlet channels 35. The appearance of the gas flow passages 11a, 11b is shown in figure 10, wherein every second passage forms an inlet passage 11a and every second passage forms an outlet passage 11b in similarity to what is mentioned previously. In this variant of the invention, the gas flows in a similar way as described above; it enters the internal cavity 20 via the first opening 4, enters the first set of channels 40 via the

first openings 4', flows through the inlet channels 11a to the reversing chamber 13 where it changes direction and flows through the outlet channels 11b to the second set of channels 41, and passes the second openings 5' into the outlet channels 35.

An advantage of using more than one sub-body, as exemplified in figure 4, is that the incoming gas flow can be divided into several smaller gas flows which increases the efficiency of the device and lowers the pressure drop over the construction. Of course, more than two sub-bodies can be arranged together. Other arrangements are also possible, one example is to arrange only one gas flow passage section 27 adjacent to the distribution section 26, and thus to block the other side of the distribution section 26. This arrangement may be used to achieve a higher mechanical stability of the construction. Another alternative is to reverse the direction of the gas flow so that the gas enters the body 3 via the outlet channels 35 and exits the body 3 through the first opening 4.

As seen from figures 3 to 10, both the distribution section 26, 26' and the gas flow passage section 27, 27' exhibit a substantially unchanged cross section in the longitudinal direction of the body. This means that these sections may be produced by extruding means which is a cost-effective production method that is suitable both for metal and ceramic material. Preferably, all sections/parts of the construction are made out of a ceramic material and joined to each other by sintering means. This gives a durable construction. To achieve a heat exchange effect between the inlet and outlet passages, the walls separating the passages must be reasonably thin. For a ceramic material a wall thickness of about 0.1 mm would give a fast heat transfer through the wall compared to the heat transfer from the gas to the wall. An example of a suitable ceramic material is cordierite.

Regarding the alternative variant of the second embodiment shown in figures 9 and 10 it is possible to produce/extrude the distribution section 26' and the gas flow passage section 27' in one piece so that the first set of channels 40 forms a part of the inlet passages 11a and the second set of channels 41 forms a part of the outlet channels 11b. The internal cavity 20 and the openings to the distribution section 26' can in such a case be arranged by inserting a pipe provided with circumferential holes as described previously. Another pipe provided with openings from the distribution section 26' can be arranged on the outside of the channel/passage structure.

A further development of the second embodiment of the invention (figs. 3 and 4) is the adaption of the device to remove particulates in the gas. Figure 11 shows schematically the principles of a gas flow filtering section 36 arranged between a gas flow passage section 27 and the section forming the reversing chamber 13. Although the design of the reversing chamber 13 may be similar to the above descriptions, it has in this case a different function as will be described below. Both the passage section 27 and the filtering section 36 are provided with gas flow inlet and outlet passages 11a, 11b as described above. Plugs 37 close the outlet passages 11b to the reversing chamber 13. The walls 39 between the passages 11a, 11b in the filtering section 36 exhibit a porous structure through which gas can pass but not particles (larger than a certain size), which at least partly will be deposited in the reversing chamber 13. These walls 39 thus work as filters. Due to the plugs 37, a pressure builds up in the reversing chamber 13. The gas flow in the inlet passages 11a is thus forced through the walls 39 in the filtering section 36 into the outlet passages 11b back to the passage section 27, as indicated by arrows in figure 11. Principally, the filtering process could be carried out in the passage section 27, but porous walls in this section would decrease the heat exchange properties. After some time, the filtering walls 39 and the reversing chamber 13 need to be regenerated by combustion of the soot. Due to the heat exchange properties of the invention, the heat evolved in this process can be utilized efficiently in that the outgoing gas preheats the incoming gas in the gas flow passage section 27. As an aid in this process, a heating coil can be placed in the reversing chamber 13. In conventional ceramic particle filters, the ash produced in the soot combustion process accumulates in the filtering channels occupying useful filter volume. According to figure 11, the ash 38 can instead at least partly be accumulated in the reversing chamber 13. In some applications, the volume of the reversing chamber 13 is sufficient for accumulating ash 38 during the service life of the gas treatment device. In other cases it is possible to provide the reversing chamber 13 with emptying means, such as an opening that is closed under normal operation.

The filtering section 36 shown in figure 11 is easily adapted to fit between the gas flow passage section 27 and the section forming the reversing chamber 13 shown in figures 3 and 4. Further, the principal shape of the filtering section 36 is the same as that of the passage section 27. Thus, also the filtering section 36 exhibits a substantially unchanged cross section in a certain direction and may therefore be produced by extruding means, be made out of a ceramic material, and joined by sintering to other ceramic sections. The plugs 37 can be arranged by conventional means during or after the extrudation process. Of course, the

filtering section 36 can be adapted to be used together with the alternative gas flow passage section 27' shown in figure 10.

Although the use of the ash-accumulating reversing chamber 13 is advantageous, it is also possible to use the filtering section 36 without the reversing chamber 13 e.g. by plugging also the inlet passages 11a or by substituting the reversing chamber 13 for a delimiting plate 24.

An advantage of using a counter-current heat exchange in the treatment of a gas flow according to the invention is that the heat can be utilized very efficiently. Besides the amount of heat contained in the incoming gas, heat may be supplied to the gas from exothermic reactions in the body, preferably by using a catalyst material that has been coated onto at least a part of the surfaces in the body that are in contact with the gas flow. Heat may also be supplied by an external source such as a heat generator preferably arranged in the reversing zone. As the outgoing gas flow during its transport from the reversing chamber 13 to the second opening 5, 5' can transfer a great deal of its heat to the incoming gas flow from the first opening 4, 4' to the reversing chamber 13, only a small part of the supplied heat will leave the body 3 with the outgoing gas flow and thus be wasted. A good heat economy is especially important if the incoming gas flow is relatively cold so that the temperature might fall below the catalyst light-off temperature described previously. An example of this is when the device is applied to purify the exhaust gases of a diesel engine.

The heat exchange process according to the invention is also very useful in temperature transient situations, such as the purification of exhaust gases during a cold start situation. In such an application of the invention, the body 3 is preferably provided with both a catalyst material and an adsorption/desorption agent applied to at least a part of the surfaces in the body 3 that are in contact with the gas flow. Said agent preferably adsorbs hydrocarbons and/or nitrogene oxides at, or below, a first temperature and releases them at, or above, a second temperature which is higher than the first temperature. As the exhaust gases enters the cold body 3, heat will be transferred from the gas to the material comprised in the body 3. The first part of the heat exchanger surfaces, i.e. the material in or close to the distribution section 26 located closest to the first opening 4, 4', heats up quickly while the part close to the reversing chamber 13 heats up slowly. As the body is arranged to permit heat exchange between adjacent passages, also the heat exchanger surfaces closest to the second opening 5, 5' will heat up quickly. A gas flow passing the device shortly after start up will thus

experience a first hot zone at the entrance of the body 3, a zone with gradually decreasing temperature (the inlet passages 11a), a zone with gradually increasing temperature (the outlet passages 11b), and a second hot zone before exit out of the body 3. Compounds adsorbed onto adsorption/desorption agents applied to surfaces in the first hot zone will relatively quickly desorb, but will be adsorbed again onto agents applied to colder surfaces close to the reversing chamber 13. As the temperature with time also increases close to the reversing chamber 13, the compounds will again desorb. This time, however, the compounds will be transported towards zones with higher temperatures. By properly designing the body and choosing catalyst material and adsorption/desorption agents, the temperature in at least the hottest zone will be above the catalyst light-off temperature so that the compounds are converted efficiently.

In order to improve the heat economy and to reduce the amounts of adsorption/desorption agents and catalysts required, one may carefully choose the body surfaces to which catalysts and agents should be applied. For instance, catalysts for oxidizing HC and CO and reducing NO_x may chiefly be applied in the hotter zones of the body (in or close to the distribution section 26), and adsorption/desorption agents may chiefly be applied in the colder zones (in or close to the reversing chamber 13).

In order to control the temperature of the gas flow in the body, the device preferably comprises one or several of the following: a heat generator arranged in the body (preferably arranged in the reversing chamber), cooling flanges arranged in the body, arrangements for introducing cooling air into the body, and/or a system for controlling the composition of the incoming gas flow. Said system preferably comprises an arrangement for introduction of oxidizing species, such as air, into the incoming gas flow, and/or an arrangement for introduction of oxidizable species, such as hydrocarbons, into the incoming gas flow. Due to the heat exchange properties of the device, the heat generated in the induced chemical reactions can effectively be taken care of.

If the device is arranged in connection to an engine, said system for controlling the composition of the incoming gas flow preferably comprises an arrangement for controlling the operation of the engine, which operation in turn can affect the composition of the incoming gas flow. For instance, by mixing additional amounts of fuel in one or several of the

cylinders one may introduce fuel, i.e. hydrocabons, into the exhaust gas that is to be purified in the gas treatment device.

The distribution section(s) is thus primarily adapted to distribute the incoming gas flow to the gas flow passages, the passage section(s) is primarily adapted to permit heat exchange and to cause a conversion in the composition of the gas, and the filtering section(s) is primarily adapted to remove particulates from the gas. Of course, this does not prevent that, for instance, heat exchange or gas conversion takes place in a distribution section, or that heat exchange takes place in a filtering section.

The invention is not limited to the above described embodiments, but a number of modifications are possible within the frame of the following claims. For instance, the reversing zone may be designed in different ways. One example is to substitute the reversing chamber 13 for transfer passages, e.g. holes, between the gas flow inlet and outlet passages.

Further, the first embodiment of the invention is not limited to the variant shown in figures 1 and 2. The zig-zag structure 2 can for instance be shaped to other geometrical structures. One example is to distribute the foldings 10 uniformly around an internal cavity so that the zig-zag structure 2 takes the form of a circular cylinder with a longitudinal internal cavity. The gas can thus be fed to the body via the cavity. A variant of this is to form a discret distribution of the foldings around the cavity wherein a number of sub-bodies is distributed around the cavity. The shape of the distribution section 26, i.e. the shape of the corrugated plates 9, may also be modified to suit different applications. Seen in the direction of the incoming gas flow, the distribution section 26 may for instance be narrowing or expanding.

Regarding the second embodiment of the invention it is possible to use a conventional monolith with a large number of narrow flow passages (and provided with the internal cavity 20) as an alternative to the gas flow passage sections 27, 27' shown in figures 6 and 10. Each of the gas flow passages in figures 6 or 10 would in such a case be substituted for a number of more narrow passages side by side. With a proper design, this arrangement would give a more stable construction and only have a slight effect on the heat exchange (due to the additional body content of material required for the additional walls). However, it would increase the pressure drop and require more material.

CLAIMS:

1. A device for treatment of a gas flow, comprising at least one body (3), at least one first opening (4, 4') for entrance of an incoming gas flow to said body (3) and at least one second opening (5, 5') for the exit of an outgoing gas flow from said body (3), wherein said body (3) is provided with a plurality of gas flow passages (11a, 11b) arranged to permit heat exchange between the gas flows in adjacent passages,
characterized in
that the device comprises at least one distribution section (26, 26') in communication with the first opening (4, 4') and with the gas flow passages (11a, 11b) to distribute the incoming gas flow to the gas flow passages (11a, 11b), and at least one gas flow passage section (27, 27') including said gas flow passages (11a, 11b), which passage section (27, 27') primarily is adapted to permit heat exchange and to cause a conversion in the composition of the gas.

2. A device according to claim 1,
characterized in
that the distribution section (26, 26') is adapted to distribute the incoming gas flow within the individual gas flow passages (11a, 11b).

3. A device according to claim 2,
characterized in
that the distribution section (26, 26') is adapted to bring about a substantially uniform gas flow within the individual gas flow passages (11a, 11b).

4. A device according to anyone of the preceding claims,
characterized in
that the distribution section (26, 26') forms a part of the body (3).

5. A device according to anyone of the preceding claims,
characterized in
that the distribution section (26, 26') is in communication with the second opening (5, 5') to also lead the outgoing gas flow out from the gas flow passages (11a, 11b).

6. A device according to anyone of the preceding claims,
c h a r a c t e r i z e d i n
that the gas flow passages (11a, 11b) extend essentially parallel to each other.

7. A device according to claim 6,
c h a r a c t e r i z e d i n
that the main direction of the gas flow in one gas flow passage (11a, 11b) is essentially the opposite of the main direction of the gas flow in at least one of the adjacent gas flow passages (11b, 11a).

8. A device according to claim 7,
c h a r a c t e r i z e d i n
that said gas flow passages (11a, 11b) form inlet passages (11a) that are intended for an incoming gas flow and outlet passages (11b) that are intended for an outgoing gas flow, and that a reversing zone (13) is arranged so that gas entering said reversing zone (13) from the inlet passages (11a) is permitted to change direction and flow back through the outlet passages (11b).

9. A device according to claim 8,
c h a r a c t e r i z e d i n
that the reversing zone comprises a reversing chamber (13).

10. A device according to anyone of the preceding claims,
c h a r a c t e r i z e d i n
that the body (3) comprises a strip (1) that is folded into a zig-zag structure (2), and that spacer means (9) are arranged between the foldings (10) of the zig-zag structure (2) in such a way that a distance is achieved between two foldings (10) that face each other in the zig-zag structure (2), and that the gas flow passages (11a, 11b) thereby are formed between the foldings (10) of the zig-zag structure (2), and that said spacer means (9) are arranged to facilitate the distribution of the incoming gas flow in the distribution section (26).

11. A device according to anyone of claims 1 to 9,

characterized in

that the body (3) comprises a strip (1) that is folded into a zig-zag structure (2), and that the surface of the strip (1) at least partly exhibits a three-dimensional pattern, preferably corrugations, and that said three-dimensional pattern is arranged to give rise to contact points and gaps between two foldings (10) that face each other in the zig-zag structure (2), and that the gas flow passages (11a, 11b) thereby are formed in the gaps between the foldings (10) of the zig-zag structure (2), and that the surface of at least one of two foldings (10) that face each other differ from said three-dimensional pattern in the distribution section (26) in such a way that the distribution of the incoming gas flow is facilitated.

12. A device according to claim 10 or 11,

characterized in

that a casing (6) provided with said first opening (4) and said second opening (5) encloses the zig-zag structure (2).

13. A device according to anyone of claims 1-9,

characterized in

that the distribution section (26, 26') and the gas flow passage section (27, 27') form separate units that are arranged together in such a way that gas can flow from one section to the other, preferably the distribution section (26, 26') and the gas flow passage section (27, 27') are joined to each other.

14. A device according to claim 13,

characterized in

that the distribution section (26) comprises a wall structure forming:

at least one first channel (29) to which the incoming gas flow is fed;

and a plurality of second channels (30) that extend from said first channel (29) and which second channels (30) are open to the gas flow passages (11a, 11b) that are intended for an incoming gas flow.

15. A device according to claim 14,

characterized in

that said first channel (29) is closed to the gas flow passages (11a, 11b).

16. A device according to claim 14 or 15,

c h a r a c t e r i z e d i n

that the wall structure forms a plurality of third channels (32) that are open to the gas flow passages (11a, 11b) that are intended for an outgoing gas flow, preferably said third channels (32) are formed between said second channels (30) using common walls.

17. A device according to claim 13,

c h a r a c t e r i z e d i n

that the distribution section (26') comprises a zig-zag shaped wall structure forming a first and a second set of channels (40, 41), one set on each side of said zig-zag shaped structure, wherein said first set of channels (40) are open to the gas flow passages (11a, 11b) that are intended for an incoming gas flow and said second set of channels (41) are open to the gas flow passages (11a, 11b) that are intended for an outgoing gas flow, and wherein the incoming gas flow is fed to the first set of channels (40).

18. A device according to anyone of claims 13 to 17,

c h a r a c t e r i z e d i n

that the distribution section (26, 26') in at least one certain direction exhibit a substantially unchanged cross section.

19. A device according to claim 18,

c h a r a c t e r i z e d i n

that the distribution section (26, 26') is produced by extruding means.

20. A device according to anyone of claims 13 to 19,

c h a r a c t e r i z e d i n

that the distribution section (26, 26') and the gas flow passage section (27, 27') are made out of a ceramic material, and that the sections are joined to each other by sintering means.

21. A device according to any of the preceding claims,

c h a r a c t e r i z e d i n

that the body (3) has a substantially cylindrical shape, preferably the body (3) has a general shape of a circular cylinder, and that the body (3) comprises an internal cavity (20) that

extends in the longitudinal direction of the body (3), and that at least one first (4, 4') or second (5, 5') opening is directed towards said cavity (20) so that the gas flow at least partly is led via said cavity (20).

22. A device according to any of the preceding claims,
characterized in
that the device comprises at least one filtering section (36), which filtering section (36) primarily is adapted to remove particulates from the gas.

23. A device according to any of the preceding claims,
characterized in
that at least a part of the surfaces in the body (3) that are in contact with the gas flow are coated with a catalyst material.

24. A device according to any of the preceding claims,
characterized in
that at least a part of the surfaces in the body (3) that are in contact with the gas flow are coated with an adsorption/desorption agent.

25. A device according to any of the preceding claims,
characterized in
that the device comprises means for controlling the temperature of the gas flow in the body (3), said means comprising one or several of the following:

- a heat generator arranged in the body (3)
- cooling flanges arranged in the body (3)
- arrangements for introducing cooling air into the body (3)
- a system for controlling the composition of the incoming gas flow.

26. A device according to claim 25,
characterized in
that said system for controlling the composition of the incoming gas flow comprises one or both of the following:

- an arrangement for introduction of oxidizing species, such as air, into the incoming gas flow

- an arrangement for introduction of oxidizable species, such as hydrocarbons, into the incoming gas flow.

27. A device according to claim 25,

characterized in

that the device is arranged in connection to a combustion engine, and that said system for controlling the composition of the incoming gas flow comprises an arrangement for controlling the operation of the combustion engine, which operation in turn affects the composition of the incoming gas flow.

28. A device according to any of the preceding claims,

characterized in

that the device is adapted to purify the exhaust gas from an internal combustion engine, preferably in a mobile application.

ABSTRACT:

The invention concerns a device for treatment of a gas flow, comprising at least one body (3), at least one first opening (4, 4') for entrance of an incoming gas flow to said body (3) and at least one second opening (5, 5') for the exit of an outgoing gas flow from said body (3), wherein said body (3) is provided with a plurality of gas flow passages (11a, 11b) arranged to permit heat exchange between the gas flows in adjacent passages. The invention is characterized in that the device comprises at least one distribution section (26, 26') in communication with the first opening (4, 4') and with the gas flow passages (11a, 11b) to distribute the incoming gas flow to the gas flow passages (11a, 11b), and at least one gas flow passage section (27, 27') including said gas flow passages (11a, 11b), which passage section (27, 27') primarily is adapted to permit heat exchange and to cause a conversion in the composition of the gas.

(Figure 3)

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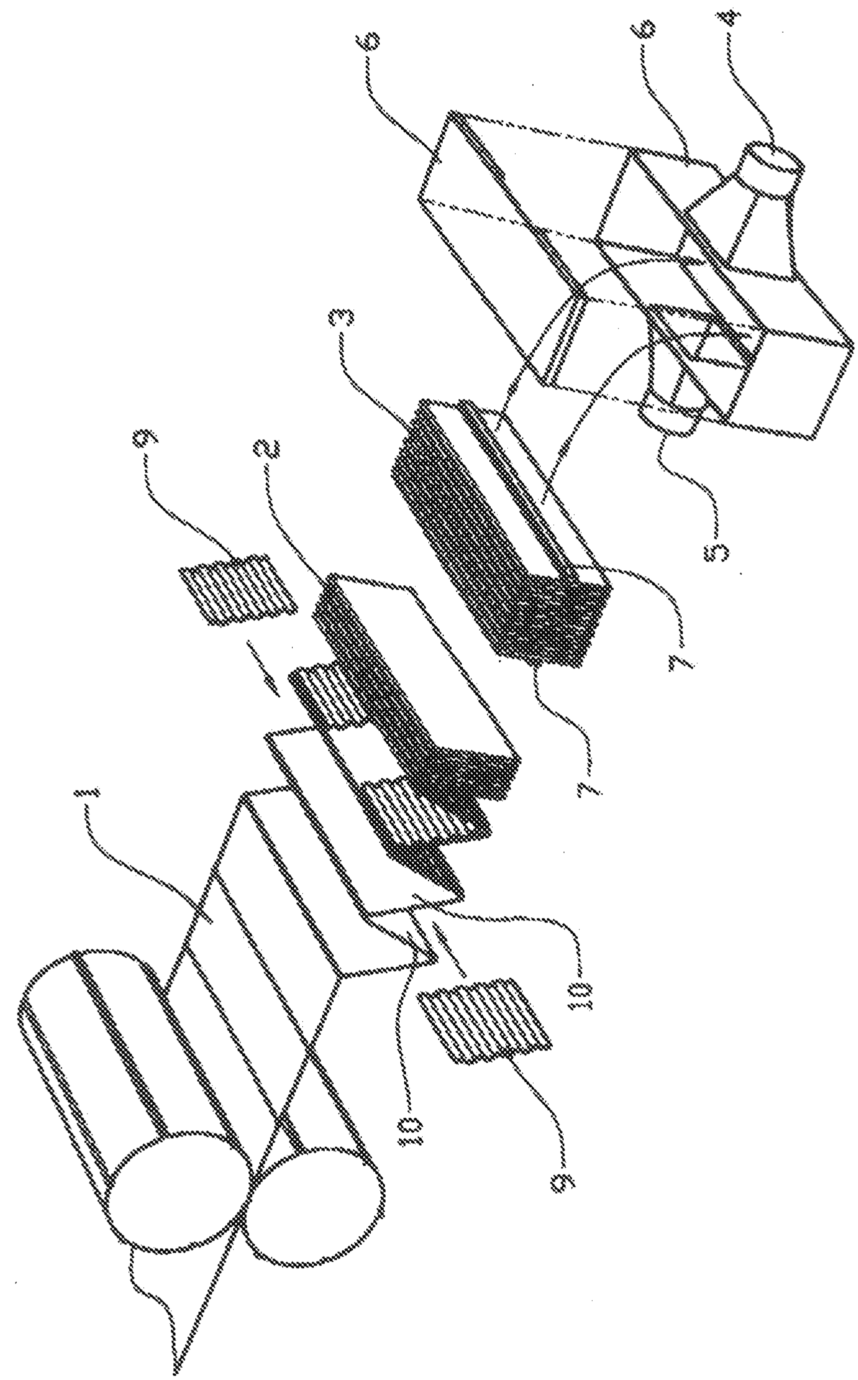


Fig.1

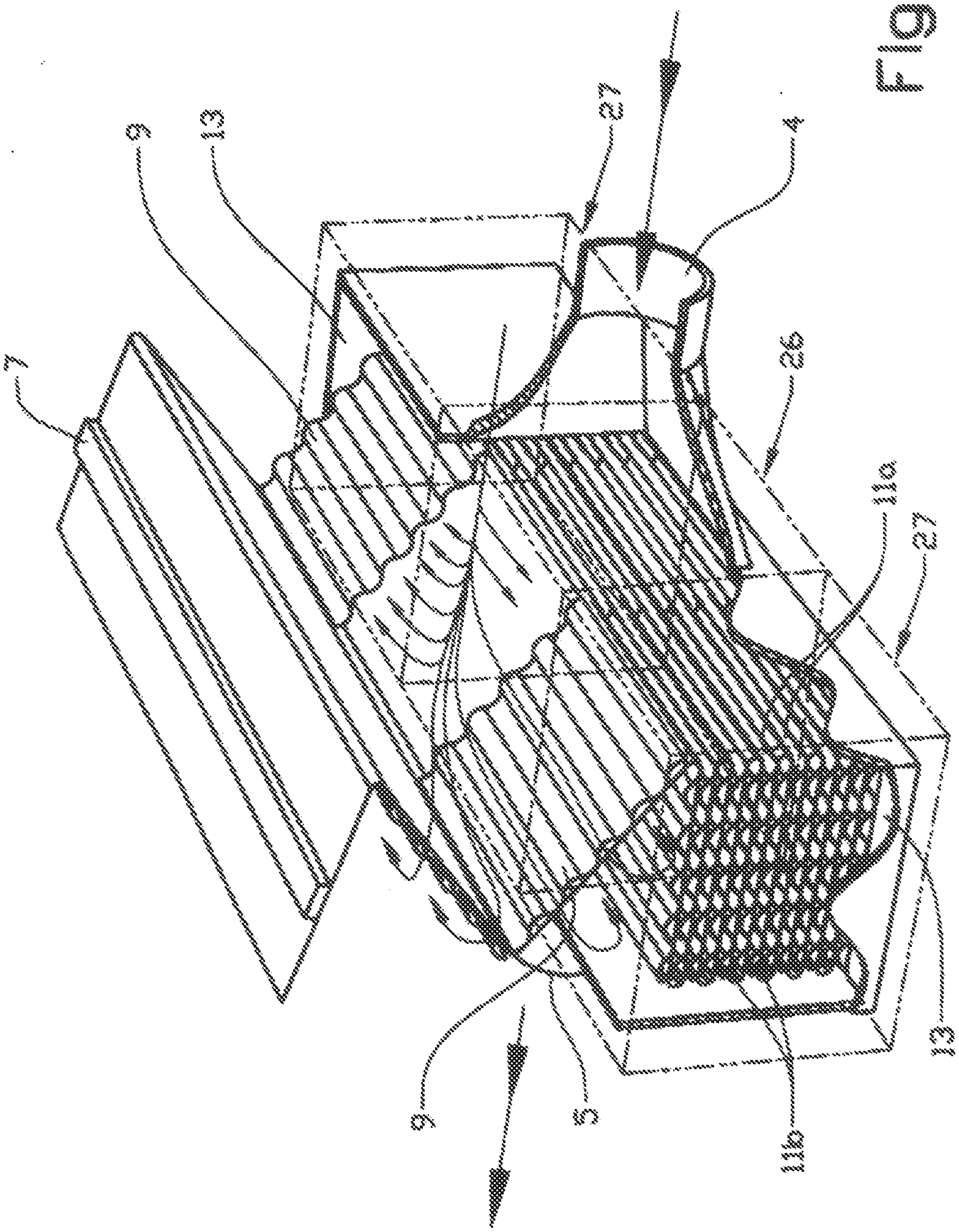


Fig.2

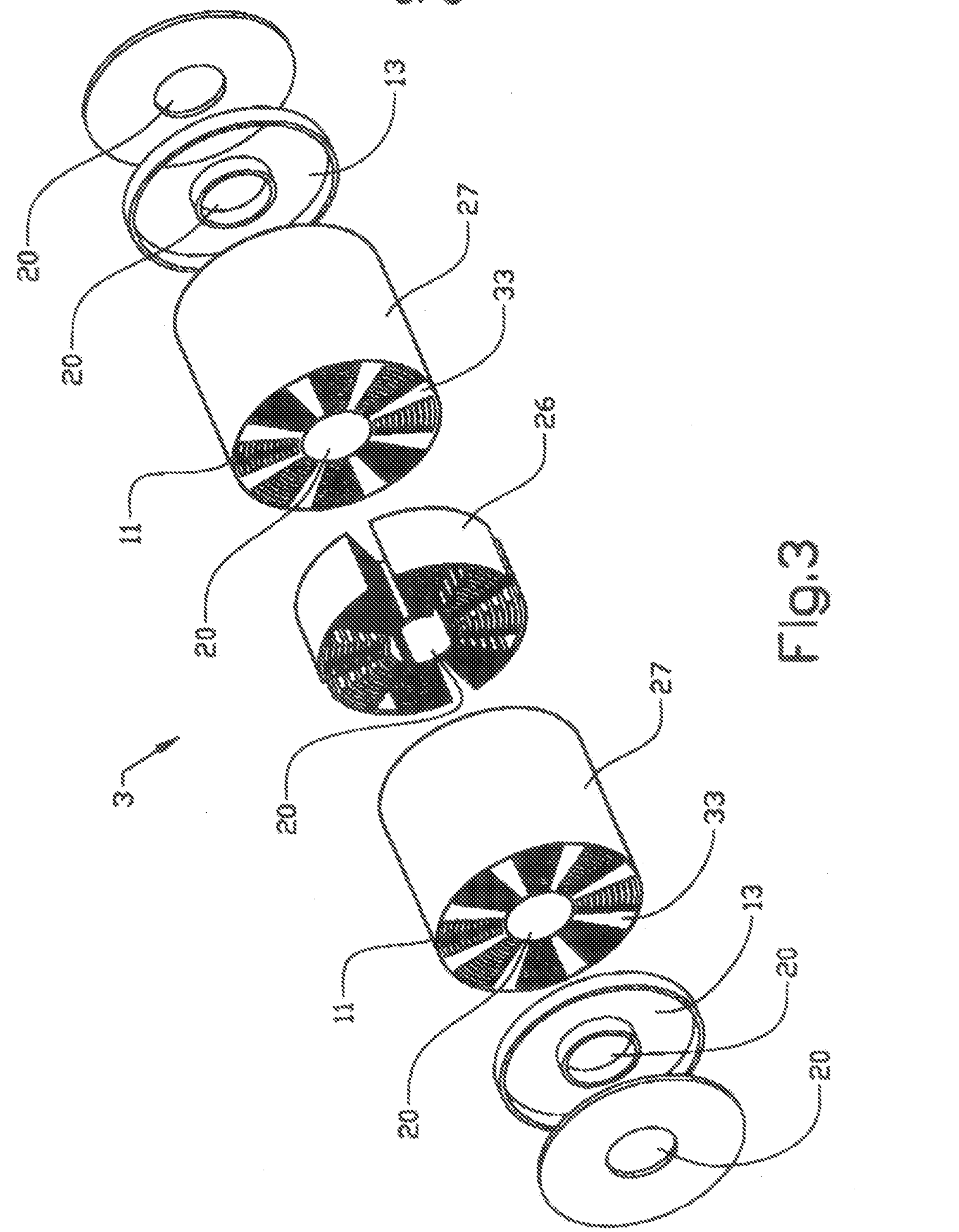


Fig.3

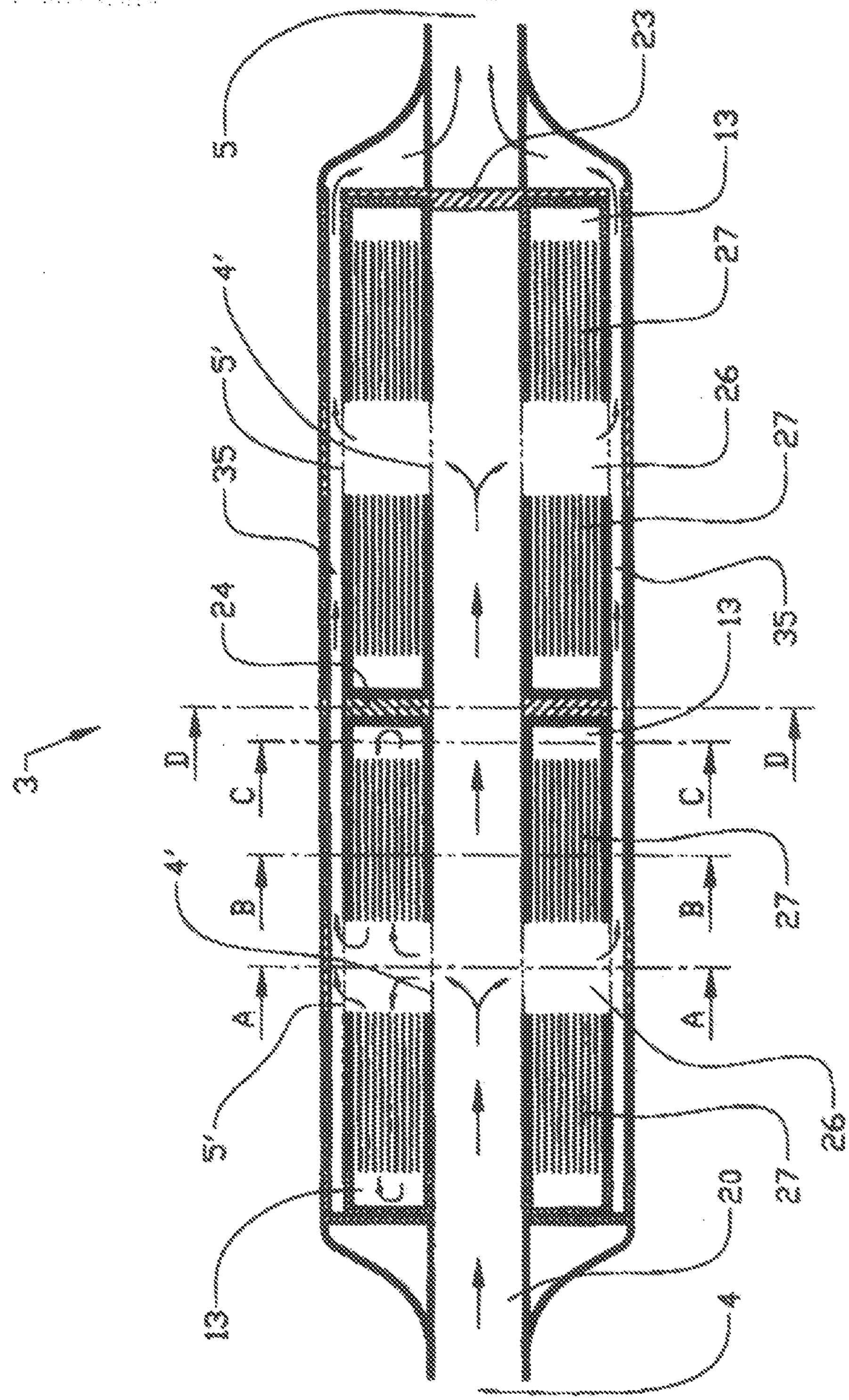
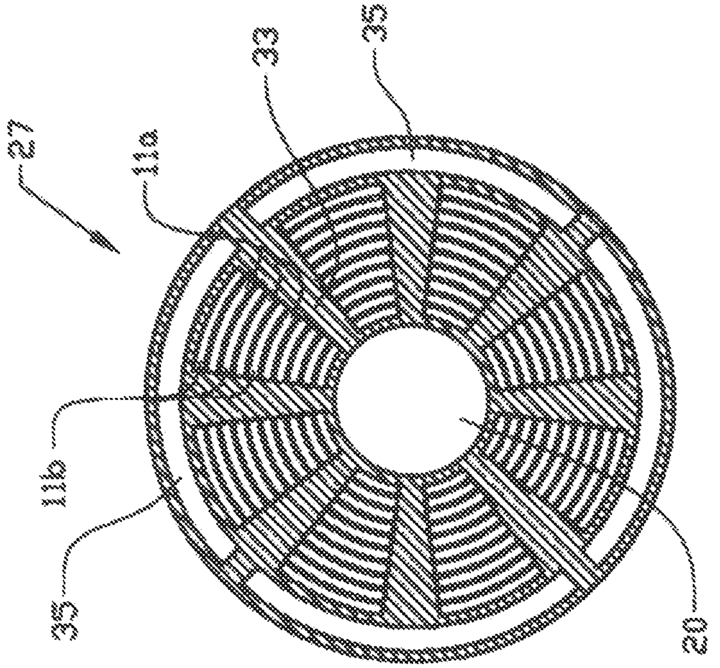
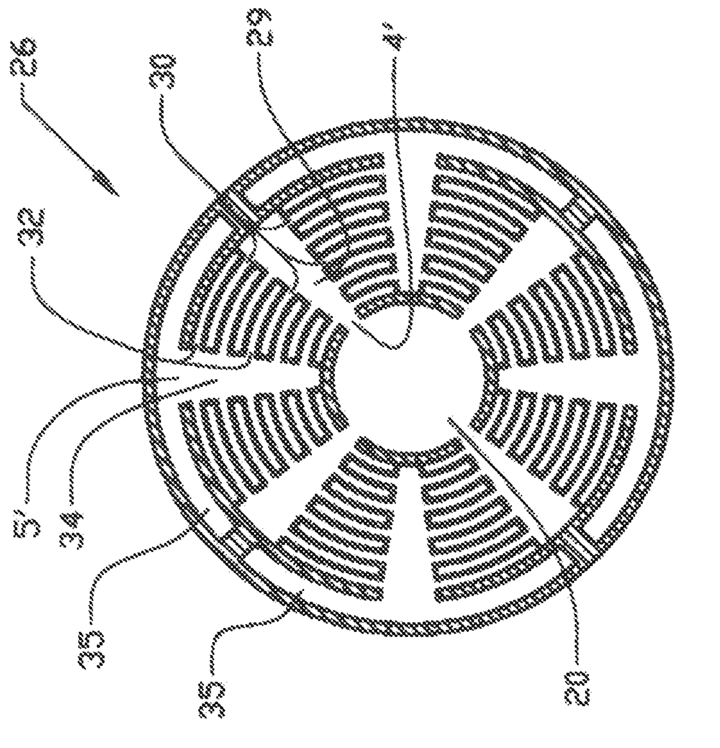


Fig.4



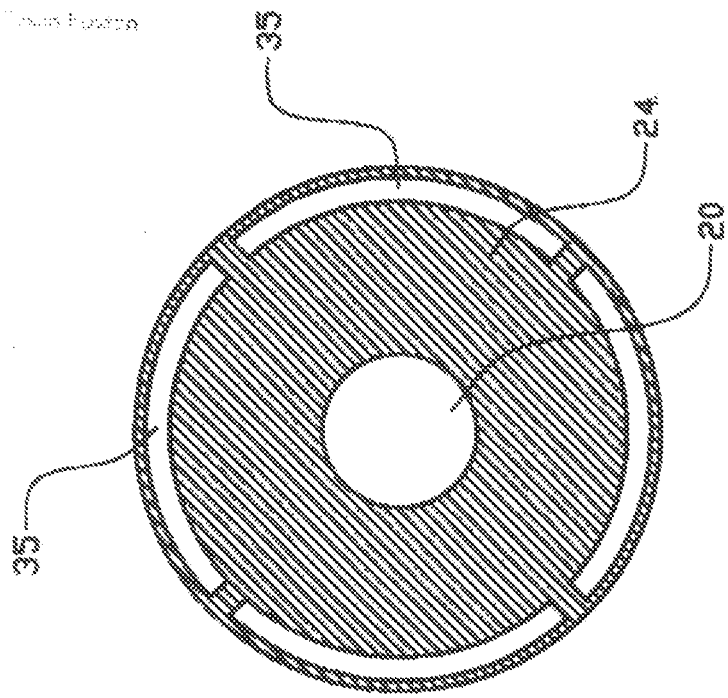
B-B

Fig.6



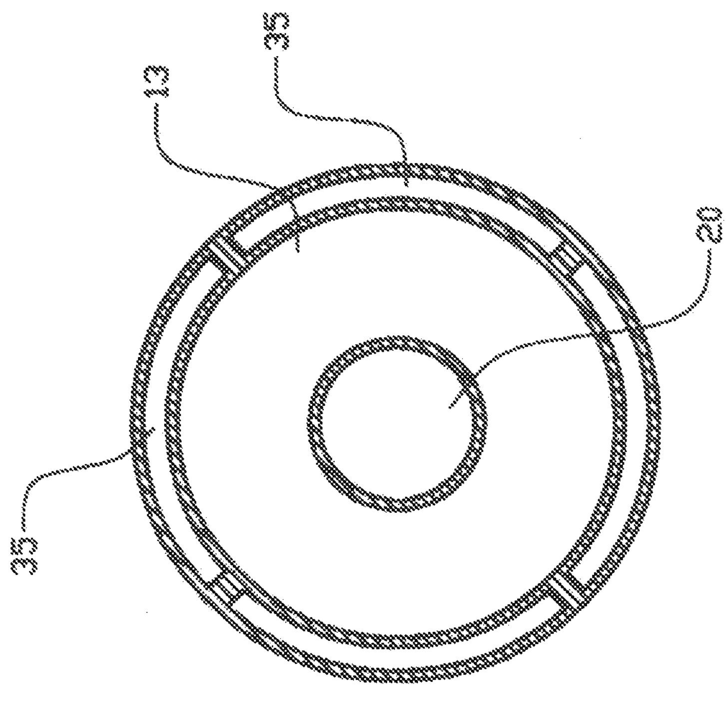
A-A

Fig.5



D–D

Fig.8



C–C

Fig.7

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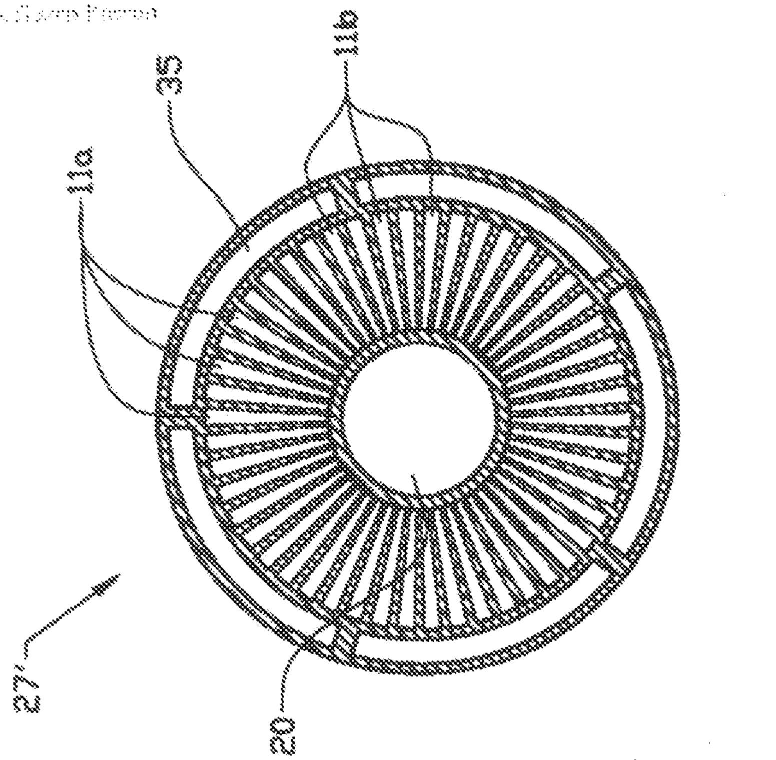
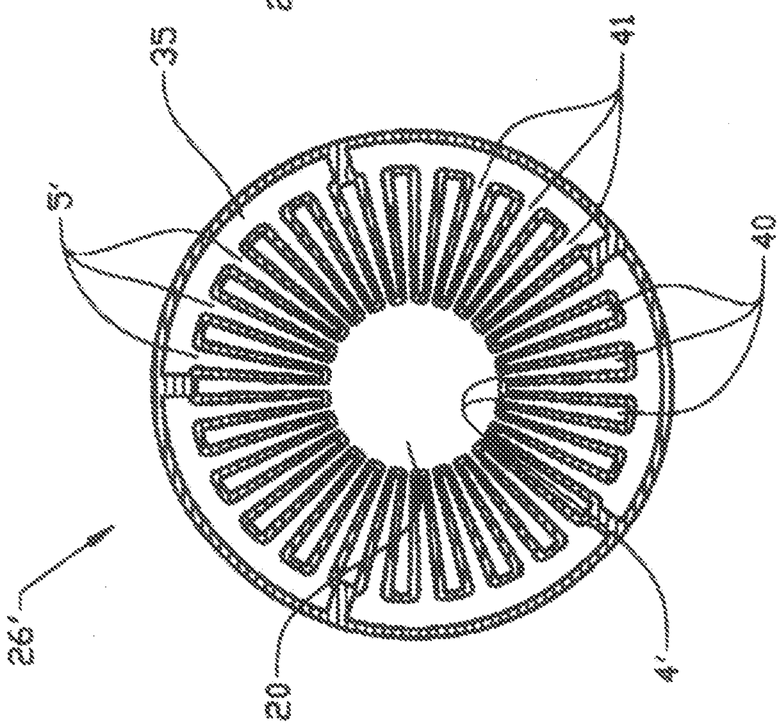


B-B

Fig.10



A-A

Fig.9

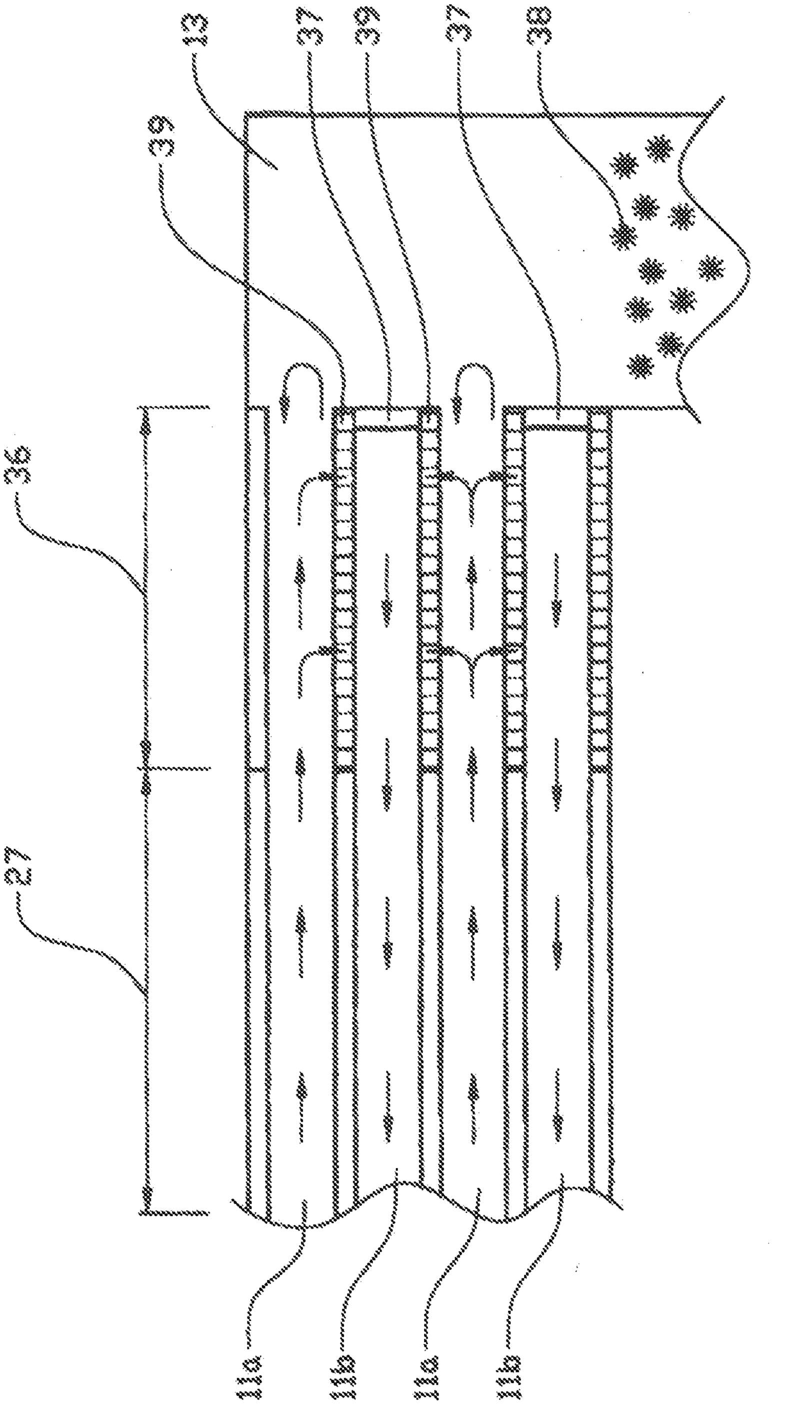


Fig.11